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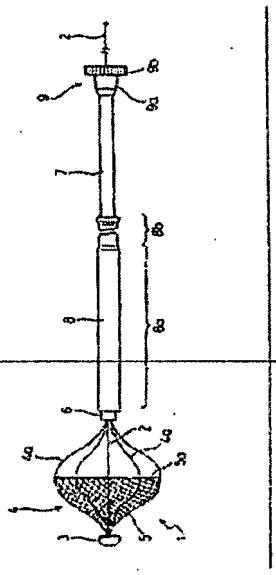
(54) [Title of the Invention] Blood filter for indwelling in artery

(57) [Abstract]
[Purpose] To provide a blood filter capable of indwelling in an artery, removable therefrom, and recoverable arrested tissue pieces and the like without any omission.
[Constitution] This blood filter 1 for indwelling in an artery comprises a collapsible and expandable filter member 5 forming arrest space with its rear end open and its forward end projected, and a filter open/close member for expanding and collapsing the filter member 5. The filter comprises more specifically a core material 2, a ring-shaped member 6 fitted thereto in such a way as to be movable, a filter retaining section 4 formed out of a plurality of elastic members with one end fixed to the core material 2 and the other end to the ring-shaped member 6, a collapsible and expandable filter member 5 forming arrest space with the rear end of the core material 2 open and the forward end projected, and a filter member open/close mechanism for moving the ring-shaped member 6 along the axial direction of the core material 2 to open and close the filter member 5.



thereof, and a collapsible and expandable filter member fixed to said filter retaining section and said hollow circular member. Here, said elastic members of the filter retaining section lie close to said main body tube and collapse said filter member when said hollow circular member is not expanded. When said hollow circular member is expanded, the other end of said elastic members is separated from the main body tube, thereby expanding said filter member.

[0008]

[Embodiments] The following is to explain some embodiments of the blood filter for indwelling in an artery according to the present invention by referring to drawings. Fig. 1 is a sectional drawing of one embodiment of the blood filter for indwelling in an artery according to the present invention. Fig. 2 is an outside drawing of the blood filter in Fig. 1 in which the filter member is expanded. Fig. 3 is a sectional drawing of another embodiment of the blood filter for indwelling in an artery according to the present invention. Fig. 4 is an outside drawing of the blood filter in Fig. 3 in which the filter member is expanded. Fig. 5 is a sectional drawing of another embodiment of the blood filter for indwelling in an artery according to the present invention. Fig. 6 is an outside drawing of the blood filter in Fig. 5 in which the filter member is expanded.

[0009] The blood filter 1 for indwelling in an artery comprises a collapsible and expandable filter member 5 forming arrest space with its rear end open and its forward end projected, and a filter open/close member for expanding and collapsing the filter member 5. Since the filter member 5 is expandable and collapsible, the filter can be indwelled on the inner wall of an artery and is removable therefrom. Furthermore, tissue pieces flowing in the artery can be arrested in the filter member 5 and recovered without any omission by collapsing the filter member 5 again after the arrest. Thus, the invention demonstrates superior effects as a filter for indwelling in an artery.

[0010] As shown in Fig. 1, the blood filter 1 for indwelling in an artery comprises more specifically a core material 2, a ring-shaped member 6 fitted thereto in such a way as to be movable, a filter retaining section 4 formed out of a plurality of elastic members with one end fixed to the core material 2 and the other end to the ring-shaped member 6, a collapsible and expandable filter member 5, which is fixed to said filter retaining section 4 and closely attaches to the inner wall of an artery on the side of the rear end in the expanded state, forming arrest space with the rear end of the core material 2 open and the forward end projected, and a filter member open/close mechanism for moving the ring-shaped member 6 along the axial direction of the core material 2 to open and close the filter member 5. In the blood filter for indwelling in an artery such as is shown in Fig. 1, the filter open/close mechanism is fixed to the ring-shaped member 6 on one end, and the other end thereof is the main body tube, that is, the member 7 for moving the ring-shaped member extended toward the rear end of the core material 2. A fixing member 9 is equipped so as to fix the member 7 for moving the ring-shaped member at a desired position of the core material. Hence, the filter member 5 can be expanded or collapsed in a sure and easy manner in this blood filter 1. Also, this blood filter can be indwelled on the inner wall of an artery and is removable therefrom. Furthermore, tissue pieces flowing in the artery can be arrested in the filter member 5 and removed without any omission by collapsing the filter member 5 again after the arrest.

[0011] The core material 2 forms the fixing section on the forward end of the filter retaining section 4 and passes through the main body tube 7 and the ring-shaped member 6, thereby forming the central axis of the blood filter according to the present invention. As the core material 2, materials having certain flexibility and rigidity are used including a stainless steel wire, a piano wire and high tensile steel for spring. The length is about 100 ~ 800 mm. The ring-shaped member 6 holds the rear end of the filter retaining section 4 that will be described below, lets the core material 2 pass through therein, is installed in such a way as to be movable relative to the core material 2, and has a hole through which the core material 2 can pass. On the rear end of the ring-shaped member 6 is fixed the forward end of the main body tube 7. On the forward end of the core material 2 is formed a forward end 3 that is round-shaped so that the device does not cause damage to a vessel wall at the time of insertion. On the forward end 3 of the core material 2 or the forward end of the core material 2 is fixed the forward end of elastic members 4a that constitutes the filter retaining section 4. The rear end of the elastic members 4a is fixed to the ring-shaped member 6. The filter retaining section 4 consists of a plurality of elastic members 4a and is nearly parallel to the core material 2 at a normal condition as shown in Fig. 1. The middle section of the elastic members 4a is not much away from the core material 2. As shown in Fig. 1, the filter retaining section is usually stored in a filter-storing member 8.

[0012] The filter retaining section 4 is formed out of a plurality (e.g., 2 ~ 8; preferably 3 ~ 6) of elastic members 4a. The elastic members 4a are made of material having certain elasticity and rigidity. More specifically, the elastic members 4a are preferably a metal wire such as a high tensile steel wire and a piano wire or a synthetic resin filament formed out of relatively high rigid resin. The length of the filter retaining section 4, that is, the length of the elastic members 4a is preferably 25 ~ 70 mm. The filter member 5 is fixed in the collapsed state between the forward end and middle section of the filter retaining section 4 as shown in Fig. 1. In the filter retaining section 4, the elastic members 4a are bent when the ring-shaped member 6 is moved toward the forward end of the core material 2, whereby the filter member 5 is expanded as shown in Fig. 2. As a result, the filter member 5 opens on the rear end side of the core material 2 and forms arrest space projected toward the forward end of the core material 2. As shown in Fig. 2, the filter member 5 is fixed to the elastic members 4a. The opening section 5a is formed in such a way as to become nearly circular when the filter member 5 is completely spread. Hence, the filter member 5 has enough room between elastic members 4a when the filter member 5 is expanded by bending the elastic members 4a. In this type of blood filter, arterial blood flows from the opening section 5a toward the forward end of the filter member 5. As a result of the blood flow, the opening section 5a of the filter member 5 or its vicinity comes to closely attach to the inner wall of the vessel. The diameter of the filter retaining section 4 is preferably 10 ~ 30 mm at the time of its expansion.

[0013] To demonstrate the abovementioned function, the filter member 5 is formed nearly in a cone shape as shown in Fig. 2. The diameter of the opening section is preferably about 10 ~ 30 mm. At the end of bending of the filter retaining section, the filter member 5 becomes collapsed between elastic members 4a. As a result, tissues pieces arrested inside the filter member 5 are stored therein, whereby they are prevented from outflowing into blood at a time when the blood filter 1 is removed from the artery. The filter member 5 is preferably a net-like material formed out of synthetic fiber such as polyolefin fiber (polypropylene fiber, polyethylene fiber), polyamide fiber and polyester fiber. Both woven and unwoven fabrics can be used. The mesh size of the filter member 5 is preferably 40 ~ 500 μm, more preferably 50 ~ 300 μm, and the most preferably 100 ~ 200 μm. Blood contains heparin at a time when the blood filter 1 is used. Therefore, we believe that blood clots do not occur by contact with the filter member. Nevertheless, the filter member 5a (sic) may be subjected to the antithrombotic processing, just to be safe. The antithrombotic processing is, for example, coating or fixing of antithrombotic material. Antithrombotic material can be any well-known material including poly (2-hydroxyethyl methacrylate), polyhydroxyethyl acrylate, hydroxypropyl cellulose, a methyl vinyl ether / maleic anhydride copolymer, a block copolymer of HEMA-ST-HEMA, thrombolytic materials (e.g., urokinase and streptokinase), and antithrombogenic materials (e.g., such polysaccharides as heparin, prostaglandin and antithrombin agents). In addition to the abovementioned coating of material, the antithrombotic processing includes a method of bonding such as an ion bonding and a covalent bonding and a method of mixing with material. Especially, the former (i.e., bonding) is preferred.

[0014] As described above, the main body tube 7 is attached with the ring-shaped member 6 on its forward end, has a lumen through which the core material 2 is passed, and is extended toward the rear end of the core material 2. The rear end of the core material 2 is projected from the rear end of the main body tube 7. The main body tube 7 is used to move the ring-shaped material 6 toward the forward end of the core material 2 by holding its rear end or middle section and moving it toward the forward end of the core material 2. In other words, the main body tube 7 constitutes a mechanism for moving the ring-shaped material 6. The main body tube 7 is preferably a flexible tube: for example, flexible synthetic resin tubes made of soft vinyl chloride resin, polyolefin elastomers (e.g., an ethylene / propylene copolymer, an ethylene / vinyl acetate copolymer and a mixture of polypropylene and polybutene), polyamide elastomers, polyester elastomers or polyurethane elastomers; and rubber tubes made of silicone rubber or latex rubber. The length of the main body tube 7 is preferably about 100 ~ 750 mm.

[0015] As described above in the case of the filter member, it is also preferable to perform the antithrombotic processing on the outer and inner surfaces of the main body tube 7 that make contact with blood. Likewise, it is also preferable to perform the antithrombotic processing on the ring-shaped member 6, the core material 2 and the forward end 3. With regard to the antithrombotic processing and material, the same such as was described above can preferably be used. On the rear end of the main body tube 7 is equipped a fixing member 9 that is used to fix the member 7 for moving the ring-shaped member to the core material at its desired position. More specifically, the fixing material 9 consists of a fixing ring member 9a attached to the rear end of the main body tube 7 and a rotating ring 9b having a screw section screwed to the ring-shaped fixing member 9a. The fixing ring member 9a has a tapered screw hole inside that reduces its diameter in the direction of the forward end. The rotating ring 9b is screwed into said screw hole and has a projected section 9c that is bent along the axial direction of the core material 2 as the screw-in progresses. As the screw-in progresses, the projected section 9c of the rotating ring 9b comes closer to the core material 2. Finally, it holds onto the core material 2, whereby the rotating ring 9b is fixed to the core material 2.

[0016] Furthermore, it is preferable to have a filter storing member 8 that can store the filter member 5 in the collapsed state and can project and store again the filter member 5 from the forward end so as to make the insertion of the blood filter 1 into an artery and removal therefrom easier. In this blood filter 1, the filter storing member 8 consists of a forward end storing section 8a of a slightly wider diameter that spans between the ring-shaped member 6 and the forward end and stores the blood filter 1 and a main body storing section 8b that extends up to the vicinity of the main body tube 2 (sic). The storing member 8 is preferably a flexible tube: for example, flexible synthetic resin tubes made of soft vinyl chloride resin, polyolefin elastomers (e.g., an ethylene / propylene copolymer, an ethylene / vinyl acetate copolymer and a mixture of polypropylene and polybutene), polyamide elastomers or polyester elastomers; and rubber tubes made of silicone rubber or latex rubber. The length of the storing member is preferably about 70 ~ 750 mm.

[0017] The following is the blood filter in Fig. 3 according to the present invention. The blood filter 20 of this embodiment has the same fundamental constitution as described in Fig. 1 except for the filter member open/close mechanism. As shown in Fig. 3, the blood filter 20 for indwelling in an artery comprises more specifically a core material 22, a ring-shaped member 26 fitted thereto in such a way as to be movable, a filter retaining section 24 formed out of a plurality of elastic members with one end fixed to the core material 2 (sic) and the other end to the ring-shaped member 26, a collapsible and expandable filter member 25, which is fixed to said filter retaining section 24 and closely attaches to the inner wall of an artery on the side of the rear end in the expanded state, forming arrest space with the rear end of the core material 22 open and the forward end projected, and a filter member open/close mechanism for moving the ring-shaped member 26 along the axial direction of said core material to open and close the filter member 25. The filter member open/close mechanism comprises a spring member 21 fixed to the core material 2 (sic) or the filter retaining section 24 on one end on the forward end of the core material 2 (sic) and fixed to the

ring-shaped member 26 on the other end and a filter storing member 28 that enables to project and store again the filter member 25 from the forward end. Hence, the filter member can be expanded or collapsed in a sure and easy manner in this blood filter 20. Also, this blood filter can be indwelled on the inner wall of an artery and is removable therefrom. Furthermore, tissue pieces flowing in the artery can be arrested in the filter member and removed without any omission by collapsing the filter member again after the arrest.

[0018] The core material 22 forms the fixing section on the forward end of the filter retaining section 4 (sic) and passes through the main body tube 7 and the ring-shaped member 6 (sic), thereby forming the central axis of the blood filter according to the present invention. As the core material 2 (sic), materials having certain flexibility and rigidity are used including a stainless steel wire, a piano wire and high tensile steel for spring. The length is about 100 ~ 800 mm. In the blood filter of this embodiment, the filter member 25 is projected from the filter-storing member 28 by pushing the core material 22 toward the forward end at the proximal end of the core material 22. Also, the filter member 25 can be stored in the filter-storing member 28 after use by pulling the core material 22 toward the rear end at the proximal end of the core material 22. For this reason, it is preferable that the core material 22 has a high torque transmission such as a piano wire and a high tensile steel wire for spring. The ring-shaped member 26 holds the rear end of the filter retaining section 24 that will be described below, lets the core material 22 pass through therein, is installed in such a way as to be movable relative to the core material 22, and has a hole through which the core material 22 can pass.

[0019] On the forward end of the core material 22 is formed a forward end 23 that is round-shaped so that the device does not cause damage to a vessel wall at the time of insertion. On the forward end 23 of the core material 22 or the forward end of the core material 22 is fixed the forward end of elastic members 24a that constitutes the filter retaining section 24. The rear end of the elastic members 24a is fixed to the ring-shaped member 26. The filter retaining section 24 consists of a plurality of elastic members 24a and is nearly parallel to the core material 22 when the blood filter is stored in the filter-storing member 28 as shown in Fig. 3. The middle section of the elastic members 24a is not much away from the core material 2 (sic). The filter retaining section 24 is formed out of a plurality (e.g., 2 ~ 8; preferably 3 ~ 6) of elastic members 24a. The elastic members 24a are made of material having certain elasticity and rigidity. More specifically, the elastic members 24a are preferably a metal wire such as a high tensile steel wire and a piano wire or a synthetic resin filament formed out of relatively high rigid resin. The length of the filter retaining section 24, that is, the length of the elastic members 24a is preferably 25 ~ 70 mm.

[0020] On the forward end of the core material 2 (sic) is equipped a spring member 21 fixed to the filter retaining section 24 on one end and to the ring-shaped member 26 on the other end. The spring member 21 is fixed in an extended state and shrinks when it is projected from the filter storing member 28, resulting in the bending of the elastic members 24a that constitute the filter retaining section 24. The spring member 21 returns to the extended state when it is stored in the filter-storing member 28 again. The diameter of the filter retaining section 4 (sic) is preferably 10 ~ 30 mm at the time of its expansion. Spring material is selected that takes such a diameter. As shown in Fig. 3, the filter member 25 is stored in the collapsed state between the forward end and middle section of the filter retaining section 24. In the filter retaining section 24, the elastic members 24a are bent at a time when the ring-shaped member 26 is moved toward the forward end of the core material 22 (in other words, as described above, at a time when the filter retaining section 24 and the spring member 21 are projected from the filter storing member 28), whereby the filter member 25 is expanded due to the contractile function of the spring member 21 as shown in Fig. 4, As a result, the filter member 25 opens on the rear end side of the core material 22 and forms arrest space projected toward the forward end of the core material 22. As shown in Fig. 4, the filter member 5 (sic) is fixed to the elastic members 24a. The opening section 25a is formed in such a way as to become nearly circular when the filter member 25 is completely spread. Hence, the filter member 25 has enough room between elastic members 24a when the filter member 25 is expanded by bending the elastic members 24a. In this type of blood filter 20, arterial blood flows from the opening section 25a toward the forward end of the filter member 25. As a result of the blood flow, the opening section 25a of the filter member 25 or its vicinity comes to closely attach to the inner wall of the vessel.

[0021] To demonstrate the abovementioned function, the filter member 25 is formed nearly in a cone shape as shown in Fig. 4. The diameter of the opening section is preferably about 10 ~ 30 mm. At the end of bending of the filter retaining section, the filter member 25 becomes collapsed between elastic members 24a. As a result, tissues pieces arrested inside the filter member 25 are stored therein, whereby they are prevented from outflowing into blood at a time when the blood filter 20 is removed from the artery. The filter member 25 preferably includes those such as was described above. The filter storing member 28, as described above, assists in projecting the section between the ring-shaped member and the forward end from the filter storing member 28 and expanding the filter member 25 by operating the core material 22. It also assists in collapsing the filter member 25 again. Furthermore, the filter-storing member 28 helps make the insertion of the blood filter 20 into an artery and removal therefrom easier.

[0022] In the blood filter 20, the filter storing member 28 consists of a forward end storing section 28a of a slightly wider diameter that spans between the ring-shaped member 6 and the forward end and stores the blood filter 1 (sic) and a main body storing section 8b (sic) that extends up to the vicinity of the rear end of the core material. The storing member 8 (sic) is preferably a flexible tube: for example, flexible synthetic resin tubes made of soft vinyl chloride resin, polyolefin elastomers (e.g., polyethylene elastomer and polypropylene elastomer), polyamide elastomers or polyester elastomers; and rubber tubes made of silicone rubber or latex rubber. The length of the storing member is preferably about 70 ~ 750 mm.

[0023] On the rear end of the storing member 28 is equipped a fixing member 29 that is used to fix the storing member 28 to the core material at its desired position. More specifically, the fixing material 29 consists of a fixing ring member 29a attached to the rear end of the storing member 28 and a rotating ring 29b having a screw section screwed to the ring-shaped fixing member 29a. The fixing ring member 29a has a tapered screw hole inside that reduces its diameter in the direction of the forward end. The rotating ring 29b is screwed into said screw hole and has a projected section 29c that is bent along the axial direction of the core material 22 as the screw-in progresses. As the screw-in progresses, the projected section 29c of the rotating ring 29b comes closer to the core material 22. Finally, it holds onto the core material 22, whereby the rotating ring 29b is fixed to the core material 22. For the same reason as described above in the embodiment of the blood filter 1, it is preferable to perform the antithrombotic processing on the places that make contact with blood including the filter member 25, the filter storing member 28, the ting-shaped member 26, the core material 22 and the external and internal surfaces of the forward end 23. With regard to the antithrombotic processing and material, the same such as was described above can preferably be used.

[0024] The following explains the blood filter of another embodiment as shown in Fig. 5. The blood filter 40 of this embodiment comprises a main body tube 41 having a fluid inflow lumen 42 inside, a expandable and shrinkable or collapsible hollow circular member 47 that passes through the main body tube 41 and closely attaches to the inner wall of an artery in the expanded state, a plurality of tubes 43 for expanding the hollow circular member that are fixed to the main body tube 41 on its one end and linked to the lumen 42 of the main body tube 41 and that on the other end extend toward the rear end of the main body tube 41, fixed to the hollow circular member 47 and linked to the inside thereof, a filter retaining section 44 consisting of a plurality of elastic members 44a installed along the tube 43 for expanding the hollow circular member and a fixing member 44b for the elastic members installed on the forward end of the elastic members 44a, and a collapsible and expandable filter member 45 fixed to the filter retaining section 44 and the hollow circular member 47. Here, the elastic members 44a of the filter retaining section 44 lie close to the main body tube 41 and collapse the filter member 45 when said hollow circular member 47 is not expanded. When the hollow circular member 47 is expanded, the other end of the elastic members 44a is separated from the main body tube 41, thereby expanding the filter member 45. The main body tube 41 is blocked at all times on its rear end and has a non-return valve 49 that opens only when a fluid injector 51 is connected therewith.

[0025] The main body tube 41 is a tube having the fluid inflow lumen 42 inside and forms a fixing section on the forward end of the filter retaining section 44, thereby constituting the basic structure of the blood filter 40 according to the present invention. The main body tube 41 is preferably a flexible tube: for example, flexible synthetic resin tubes made of soft vinyl chloride resin, polyolefin elastomers (e.g., polyethylene elastomer, polypropylene elastomer, an ethylene / propylene copolymer, an ethylene / vinyl acetate copolymer, and a mixture of polypropylene and polybutene), polyamide elastomers, polyester elastomers or polyurethane elastomers; and rubber tubes made of silicone rubber or latex rubber. The length of the main body tube is preferably about 100 ~ 800 mm.

[0026] The hollow circular member 47 lets the main body tube 41 pass there through, is expandable and shrinkable or collapsible, and closely attaches to the inner wall of an artery in the expanded state. The hollow circular member 47 is linked to the lumen 42 of the main body tube 41 through the tube 43 for expanding the hollow circular member, whereby fluid that flows into the lumen 42 of the main body tube 41 expands the hollow circular member. The hollow circular member 47 can be made of either extendable materials or hardly extendable materials. In the former case, the hollow circular member expands as the materials are extended by the inflow of fluid. In the latter case, it expands by the inflow of fluid. The hollow circular member is preferably made of materials that are extendable to some degree. Such materials enable the device to be more closely attached to the inner wall of an artery, resulting in less damage to the inner wall. The exterior diameter of the hollow circular member 47 is about 10 ~30 mm at the time of its expansion. Extendable materials are preferably extendable synthetic resin such as polyolefin elastomers (e.g., polyethylene elastomer, polypropylene elastomer, an ethylene / propylene copolymer, an ethylene / vinyl acetate copolymer, and a mixture of polypropylene and polybutene), polyamide elastomers, polyester elastomers and polyurethane elastomers and rubber such as silicone rubber and latex rubber. Hardly extendable materials are preferably polyolefin such as polyethylene, polypropylene and an ethylene / propylene copolymer, such polyester as polyethylene terephthalate, and thermoplastic resin such as polyvinyl chloride, an ethylene / vinyl acetate copolymer, a bridge-style ethylene / vinyl acetate copolymer, polyurethane and polyphenylene sulfide.

[0027] The tubes 43 for expanding the hollow circular member is, as shown in Fig. 5, equipped to the forward end of the main body tube 41 in such a way as to be branched out and linked to the lumen 42 of the main body tube 41. The other end extends toward the rear end of the main body tube 41, is attached to the hollow circular member 47, and is linked to its inside. It is preferable that a plurality of the tubes 43 for expanding the hollow circular member is used (preferably 2 ~ 8, and more preferably 3 ~ 6). The filter retaining section 44 consists of a plurality of elastic members 44a along the tube 43 for expanding the hollow circular member and a fixing section 44b for the elastic members on the forward end of a plurality of the elastic members 44a. The elastic members 44a are nearly parallel to and lie close to the main body tube at a normal state as shown in Fig. 5. Fluid that flows into the device through the lumen 42 fills the tube 43 for expanding the hollow circular member and fills and expands the hollow circular member 47. Consequently, the elastic members 44a are pushed by the hollow circular member 47, spread out on the other end, and then separated from the main body tube 41, as shown in Fig. 6. The forward end of the fixing section 44b has a round shape so that no damage is caused to the vessel wall at the time of insertion.

[0028] The elastic members 44a can be made of a synthetic resin having certain elasticity and rigidity such as polycarbonate, polystyrene and polyamide, piano steel or stainless steel. It is also possible that the fixing section 44b is formed out of a synthetic resin, and the elastic members 44a are made of piano steel or stainless steel. The filter retaining section 44 and the elastic members 44a are preferably about 25 ~ 70 mm in length. The filter retaining section 44 is preferably formed out of a plurality of the elastic members 44a (e.g., 2 ~ 8, and preferably 3 ~ 6). The tube 43 for expanding the hollow circular member is preferably fixed to the inner surface of the elastic members 44a of the filter retaining section 44. In this manner, the elastic members 44a can be transformed easily by force of the hollow circular member 47 and the tube 43 for expanding it at the time of the expansion of the hollow circular member 47. As a result, the filter member 45 can also be expanded without fail as explained below.

[0029] As shown in Fig. 5, the filter member 45 is fixed in the section between the forward end and middle section of the filter retaining section 44 in the collapsed state. The filter retaining section 44 is, as described above, transformed by the expansion of the hollow circular member 47, thereby expanding the filter member 45. As a result, the filter member 45 opens on the rear end side of the main body tube 41 and forms arrest space projected toward the forward end of the main body tube 41. As shown in Fig. 6, the filter member 45 is fixed to the elastic members 44a and the hollow circular member 27 and formed in such a way as to become nearly circular cross-sectionally at a time when the filter member 45 is completely spread. Hence, the filter member 45 may have enough room between elastic members 44a even when the hollow circular member 47 expands to closely attach to the inner wall of an artery. In this type of blood filter 40, arterial blood flows from the rear end toward the forward end of the filter member 45. As a result of the blood flow, the rear end of the filter member 45 or its vicinity comes to closely attach to the inner wall of the vessel.

[0030] To demonstrate the abovementioned function, the filter member 45 is formed nearly in a cone shape as shown in Fig. 6. At the end of bending of the filter retaining section 44, the filter member 45 becomes collapsed between elastic members 4a (sic). As a result, tissues pieces arrested inside the filter member 45 are stored therein, whereby they are prevented from outflowing into blood at a time when the blood filter 40 is removed from the artery. The filter member 45 is preferably a net-like material formed out of synthetic fiber such as polyolefin fiber (polypropylene fiber, polyethylene fiber), polyamide fiber and polyester fiber. Both woven and unwoven fabrics can be used. The mesh size of the filter member 45 is preferably 40 ~ 500 μm, more preferably 50 ~ 300 μm, and the most preferably 100 ~ 200 μm.

[0031] The main body tube 41 is blocked at all times on its rear end and has a non-return valve 49 that opens only when such a fluid injector 51 as a syringe is connected therewith. In the blood filter 40 of this embodiment, the forward end thereof can easily be inserted into an artery by reducing air quantity inside the blood filter 40 (i.e., inside the lumen 42, the tube 43 for expanding the hollow circular member and the hollow circular member 47) by force of suction of a syringe. After its insertion into an artery, fluid such as saline solution and an X-ray contrast medium is injected with the syringe, whereby the hollow circular member 47 and the tube for expanding the hollow circular member are expanded.

[0032]

[Operation of the Invention] The following explains the operation of the blood filter for indwelling in an artery according to the present invention by referring to Figs. 1, 2, 7 and 8. After opening the chest region, the blood filter 1 of the invention is inserted into the upper portion of the cardiac ascending artery and the upstream of the aortic arch. As shown in Fig. 1, the blood filter is inserted so that its forward end is placed in the downstream of the artery, wherein the filter member 5 is not yet expanded (i.e., the filter member 5 is stored in the filter storing member 8). As shown in Figs. 2 and 7, the filter member 5 is projected from the forward end of the filter storing member 8. Then, the rotating ring 9b of the fixing member 9 attached to the rear end of the main body tube 7 is unscrewed, and the main body tube 7 is pushed toward the forward end while holding the core material 2 by hand. As a result, the elastic members 4a of the filter retaining section 4 is bent, whereby the filter member 5 is expanded. Next, the rotating ring 9b of the fixing member 9 is rotated when the retaining section 4a (sic) nearly makes contact with the inner wall of an artery, and it is fixed to the core material so as to maintain the expanded state of the filter member 5. Since arterial blood is flowing toward the forward end of the filter member 5 from the opening section thereof, the periphery area of the filter member 5 or its vicinity come to closely attach to the inner wall of the artery by force of blood flow, as shown in Fig. 7.

[0033] As shown in Fig. 7, a blood transmission cannula 53 is inserted into a cardiac ascending artery 52 and the upstream of the blood filter 1. A blood removal cannula (not shown in the drawing) is inserted into a cardiac ascending / descending vein. Then, an extracorporeal circuit is formed by connecting the blood transmission cannula 53 and the blood removal cannula to an artificial cardiopulmonary device with a tube. At the end of open heart surgery, the rotating ring 9b of the fixing member 9 attached to the rear end of the main body tube 7 is unscrewed, and the main body tube 7 is pulled toward the rear end while holding the core material 2 by hand. As a result, the elastic members 4a of the filter retaining section 4 becomes linear, that is, the filter member 5 is collapsed inside the elastic members 4a. Tissue pieces arrested by the filter member 5 are captured inside thereof after it is collapsed. Also, the filter member 5 is stored in the filter-storing member 8 again. Then, the blood filter 1 is removed from the artery.

[0034] In the case of severe arteriosclerotic lesions in a cardiac ascending artery, we can insert a blood transmission cannula into an iliac artery and the blood filter 1 of the present invention into the other iliac artery, instead of the cardiac ascending artery, as shown in Fig. 8. Accordingly, it is preferable that the blood filter 1 is long enough to be inserted from an iliac artery. As shown in Fig. 8, the blood filter 1 allows the filter member to be expanded and prevents tissue pieces of arteriosclerotic lesions in the abdominal or thoracic aorta from flowing into coronary arteries by arresting them.

[0035]

[Effects of the Invention] The blood filter for indwelling in an artery according to the present invention comprises a collapsible and expandable filter member forming arrest space with its rear end open and its forward end projected, and a filter open/close member for expanding and collapsing the filter member. Since the filter member is expandable and collapsible, the filter can be indwelled on the inner wall of an artery and is removable therefrom. Furthermore, tissue pieces flowing in the artery can be arrested in the filter member and removed without any omission by collapsing the filter member again after the arrest. Thus, the invention demonstrates superior effects as a filter for indwelling in an artery.

[Brief explanation of Drawings]

[Fig. 1] Fig. 1 is a sectional drawing of one embodiment of the blood filter for indwelling in an artery according to the present invention.

[[Fig. 2] Fig. 2 is an outside drawing of the blood filter in Fig. 1 in which the filter member is expanded.

[[Fig. 3] Fig. 3 a sectional drawing of another embodiment of the blood filter for indwelling in an artery according to the present invention.

[[Fig. 4] Fig. 4 is an outside drawing of the blood filter in Fig. 3 in which the filter member is expanded.

[[Fig. 5] Fig. 5 is a sectional drawing of another embodiment of the blood filter for indwelling in an artery according to the present invention.

[[Fig. 6] Fig. 6 is an outside drawing of the blood filter in Fig. 5 in which the filter member is expanded.

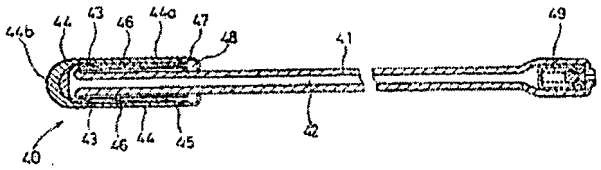
[Fig. 7] Fig. 7 is an explanatory drawing showing the operation of the blood filter according to the present invention.

[Fig. 8] Fig. 8 is an explanatory drawing showing the operation of the blood filter according to the present invention.

[Explanation of Reference Numerals]

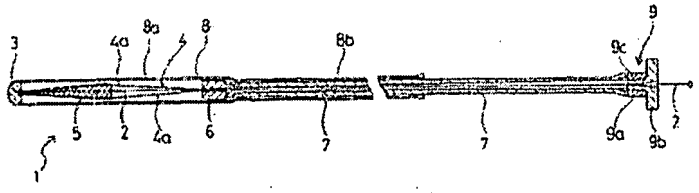
1. Blood filter for indwelling in an artery
2. Core material
3. Forward end
4. Filter retaining section
4a. Elastic members
5. Filter member
6. Ring-shaped member
7. Main body tube
8. Filter storing member
9. Fixing member
20. Blood filter for indwelling in an artery
40. Blood filter for indwelling in an artery

[Fig. 5]

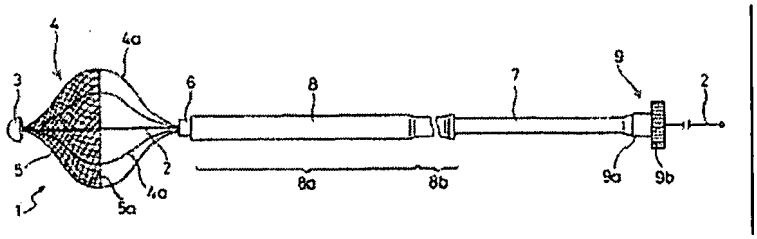


(9)

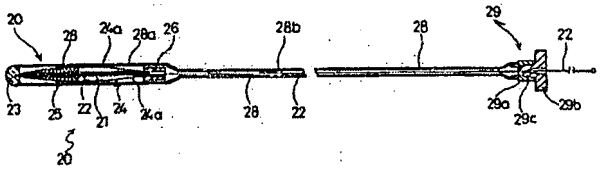
[Fig. 1]



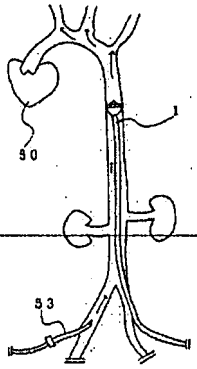
[Fig. 2]



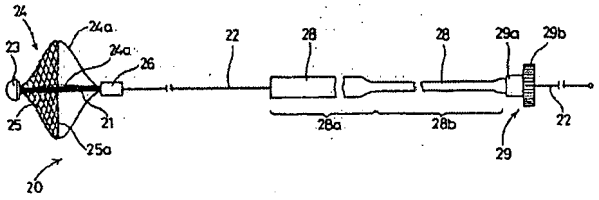
[Fig. 3]



[Fig. 8]

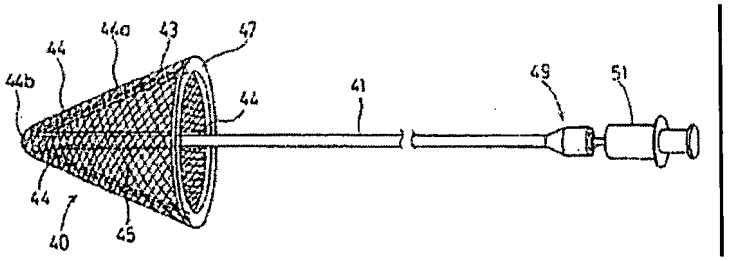


[Fig. 4]

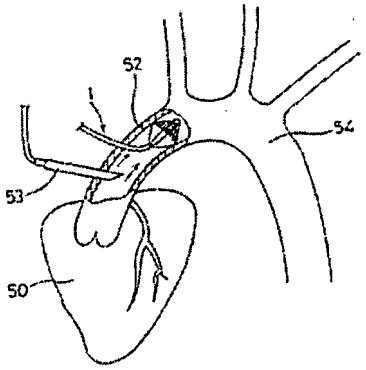


(10)

[Fig. 6]



[Fig. 7]



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CERTIFICATION OF ACCURACY

I CERTIFY, UNDER PENALTY OF PERJURY UNDER THE LAWS OF THE UNITED STATES OF AMERICA THAT WE ARE COMPETENT IN **ENGLISH** AND **JAPANESE** AND THAT THE FOLLOWING ARE, TO THE BEST OF OUR KNOWLEDGE AND BELIEF, A TRUE, CORRECT, COMPLETE AND ACCURATE TRANSLATION OF THE ORIGINAL **DOCUMENTS REGARDING JAPANESE PATENTS 62-4981 AND H7-12451.**

MAY 17, 2007

MARIAM NAYINY
PRESIDENT
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